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Effect of Postharvest Calcium and Fungicide Treatments on Rhizopus Rot and Storage Life of 'Earligrande' Peaches

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ABSTRACT

'EarliGrande' peaches were treated after harvest with solutions containing 0.05 gl^{-1} captan and 0, 2, 4, 6 or 8 percent calcium chloride ($CaCl_2$) by dipping. One lot of fruit was inoculated with a conidial suspension (1 x 10^4 spores ml^{-1}) of *Rhizopus stolonifer* (Ehrenb. ex. Fr.) Lind, stored at 4, 10 or 20°C for 4 weeks and rated for decay severity. The other lot of treated peaches was placed in storage for 8 weeks at 4°C and percentages of marketable fruit were determined every 2 weeks. Combinations of 2 or 4 percent $CaCl_2$ with captan gave the most effective control of Rhizopus rot and extended the shelf-life and marketability of uninoculated peaches.

RESUMEN

Frutos de durazno cultivar 'EarliGrande' fueron tratados después de la cosecha mediante inmersión en soluciones conteniendo 0.05 g/litro de captán y 0, 2, 4, 6 u 8 por ciento de cloruro de calcio ($CaC1_2$). Un grupo de frutos fue inoculado con una suspensión conidial (1 X 10^4 esporas/ml) de *Rhizopus stolonifer* (Ehrenb. ex. Fr.) Lind, almacenado a 4, 10, o 20°C por 4 semanas y clasificado de acuerdo a la severidad de la pudrición. El ortro grupo de duraznos tratados fue almacenado por 8 semanas a 4°C y cada dos semanas se determinaron los porcentajes de frutos comercializables. Las combinaciones de 2 o de 4 por ciento de $CaC1_2$ con captán produjeron el control más efectivo para la pudrición causada por Rizhopus y extendieron la vida en almacén y la comerciabilidad de los durazno no inoculados.

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Peaches (*Prunus persica* (L.) Batsch) are perishable fruit which have a cool-storage life that ranges from 2 to 6 weeks, depending on cultivar (Singh et al., 1982). Peaches tend to ripen and senesce rapidly at ambient temperatures, which results in postharvest decay and wastage during handling (Lill et al., 1989). Decay is a major problem in the handling of peaches after harvest and can result in appreciable losses at wholesaler, retailer and consumer levels (Ceponis and Cappellini, 1985). *Rhizopus stolonifer* (Ehrenb. ex. Fr.) Lind is one of the major causes of postharvest decay of peaches in transit (Harper et. al., 1972; Nguyen and Souty, 1985; Singh and Prashar, 1985). Although the fungus is sensitive to cold temperatures, it is much less sensitive to fungicide treatment and very few fungicides are effective in its control (Bompeix et al., 1979). Studies have shown that increasing the calcium content of peaches extends the storage life (Gupta et al., 1984), maintains fruit quality (Gautam et al., 1981) and reduces postharvest decay (Conway et al., 1987).

The peach is one of the leading deciduous tree fruits grown in Texas and production in the Rio Grand Valley has become profitable (Sauls, 1985). To reduce occurrence of Rhizopus rot on peaches produced in the Rio Grande Valley, it may be necessary to spray fruit with various recommended fungicides, including captan (N-Trichloromethyl- thio-4-cyclohexane-1,2-dicarboximede) shortly before maturity (Heyns, 1968) to prevent infection in the orchard or apply fungicide dips to deactivate incipient infections (Heaton, 1980). The objectives of this study were to determine the effect of postharvest calcium and captan treatments on storage rot of peaches caused by *R. stolonifer* and shelf life of 'EarliGrande' peaches grown in south Texas

MATERIALS AND METHODS

'EarliGrande', an early cultivar of peaches grown in the Rio Grande Valley of Texas (Rouse, 1985), was used in this study. Fruit were harvested just as the ground color began to change to yellow on April 11, 1990 and April 4, 1991 respectively. They were randomly selected and dipped in solutions of distilled water containing 0 to 8 percent w/v calcium chloride ($CaCl_2$) and 0.05 g l^{-1} captan. Distilled water served as the control. Following treatment, the fruit were placed on Kraft paper boards and allowed to drain dry for 1 hr, and then divided into two lots. One lot was inoculated by puncturing with the head of a nail (1 mm diam) in four numbered quadrants and was then submerged for 30 sec in a conidial suspension of *R. stolonifer* (1 x 10^4 spores ml^{-1}) in a nutrient broth containing 0.5% Tween-20. Inoculated fruit were divided into three groups and stored at 4, 10 or 20°C ± 1°C for 4 wks. After storage, fruit were rated for decay severity by measuring the two orthogonal diameters of decay area as the mean of its width and length and then computing the area of decay from the formula πab, where a and b are the respective diameters (Conway et al., 1987). There were four replications with 15 fruit in each treatment.

Table 1. Effects of calcium and captan on decay severity of *Rhizopus*-inoculated 'EarliGrande' peaches at three storage temperatures.

Treatment	Decay area (mm^2)[z]		
	4°C	10°C	20°C
control	117 a[y]	230 a	352 a
captan (0.05g/L)[x]	49 c	151 d	204 c
2% $CaCl_2$	52 c	142 d	244 b
4% $CaCl_2$	58 c	146 d	196 c
6% $CaCl_2$	87 b	165 cd	257 b
8% $CaCl_2$	123 a	207 b	334 a
2% $CaCl_2$ + captan	21 d	102 e	171 c
4% $CaCl_2$ + captan	26 d	99 e	126 d
6% $CaCl_2$ + captan	78 b	168 c	247 b
8% $CaCl_2$ + captan	109 a	211 b	313 a

[z]Decay area was calculated by measuring the two orthogonal diameters of decayed tissues and then computing the area of decay from the formula πab, where a and b are respective diameters.

[y]Means in a column followed by the same letter are not significantly different at P= 0.05 level according to Duncan's multiple range test.

[x]Fungicide concentration represents active ingredient.

The other lot of uninoculated fruit was held in a storage chamber (4° ± 1°C and 85 percent ± 5 percent RH) for 8 weeks and assessed for shelf-life. Shelf-life was defined as the average number of days that the majority of fruit (> 50 percent) remained marketable under the storage conditions. Fruit marketability was limited by rotting, textural oversoftening and senescent breakdown. Percentage of marketable fruit was calculated at 2-week intervals for each treatment by subtracting the number of unmarketable ones from the initial number, dividing by the initial number and multiplying by 100. There were four replications with 15 fruit in each treatment.

The dried peels were used for Ca determination. Composite fresh peel samples from five individual fruit from each treatment in the second lot were air dried for 72 hr at 20°C, then oven dried at 65°C for 24 hr and ground in a Wiley mill. A 1.0-g sample was dry ashed at 500°C prior to analysis for total Ca using atomic absorption spectroscopy.

All experiments were repeated twice during 1990 and 1991 growing seasons. The data, which represent means from 1990 and 1991 experiments, were pooled after running a test of homogeneity of variance. The data were analyzed by the analysis of variance (ANOVA) procedure.

RESULTS AND DISCUSSION

There was a significant reduction in decay severity in *Rhizopus*-inoculated peaches treated with captan, $CaCl_2$ and combinations at all storage temperatures (Table 1). Fruits treated with captan alone or with 2, 4 and 6 percent $CaCl_2$ solutions had respective mean decay areas of 49, 52, 58 and 87 mm^2, which translated to about 60, 55, 50 and 25 percent less decay, respectively, than untreated fruit (117 mm^2 decay area) stored at 4°C. The mean decay area (123 mm^2) on fruit treated with 8 percent $CaCl_2$ was not different from untreated fruit stored at 4°C, while the combination of captan and 2 or 4 percent $CaCl_2$ resulted in decay areas of 21 and 26 mm^2, respectively, which were about 80 percent less than that of controls. The combination of captan and 6 or 8 percent $CaCl_2$ resulted in a respective decay areas of 78 and 109 mm^2, which were only 30 and 10 percent less than controls at 4°C. By dropping storage temperature from 20°C to 10°C, decay retardation in controls was as good as treating with captan or $CaCl_2$ alone at 20°C. Similarly, by dropping temperature to 4°C from 10°C, the dacay severity on untreated fruit was less than all except for 2 and 4 percent $CaCl_2$ + captan. Although the efficacies of captan, $CaCl_2$ and the combination of $CaCl_2$ and captan in reducing storage decay decreased with increasing storage temperatures, fruits treated with 2 or 4 percent $CaCl_2$ with captan consistently developed less decay than other treated fruit at all storage temperatures tested (Table 1). The best combination of treatments to retard decay of *Rhizopus*-inoculated fruit was either 2 or 4 percent $CaCl_2$ + captan at 4°C.

The differences in efficacy of $CaCl_2$ treatments in reducing storage decay caused by R. *stolonifer* may be attributed to direct effects of $CaCl_2$ on either the pathogen or the fruit. Although calcium is essential for enzyme activation and membrane integrity of many fungi, it has been shown to have a toxic effect on overall fungal growth and development at certain concentrations (Cameron and LeJohn, 1972). In a previous in vito study (unpublished), the authors found that the inhibition of *R. stolonifer* growth increased with increasing $CaCl_2$ concentration in the culture media. The ineffectiveness of higher concentrations (6 or 8 percent) of $CaCl_2$, alone or in combination with captan, for controlling storage decay in this study may be because of damage to the epidermal tissues of the peaches. Lill et al.

Table 2. Effects of postharvest calcium and captan treatments on shelf-life and calcium content of 'EarliGrande' peaches stored at 4°± 1°C and 85 ± 5% relative humidity for 56 days.

Treatment	Shelf-life (days)	Peel calcium content (µg/g dried tissue)
control	5.8 e[z]	136.5 d
captan (0.05g/L)[y]	9.2 de	139.4 d
2% $CaCl_2$	12.4 d	198.4 c
4% $CaCl_2$	16.8 c	233.7 b
6% $CaCl_2$	19.5 bc	249.6 b
8% $CaCl_2$	18.8 bc	289.8 a
2% $CaCl_2$ +captan	35.2 a	213.7 c
4% $CaCl_2$ + captan	38.6 a	226.5 bc
6% $CaCl_2$ + captan	21.8 b	246.9 b
8% $CaCl_2$ + captan	20.2 bc	279.3 a

[z]Means in a column followed by the same letter are not significantly different at the P= 0.05 level according to Duncan's multiple range test.

[y]Fungicide concentration represents active ingredient.

(1989) reported that increasing concentrations of $CaCl_2$ in excess of 2 percent may severely damage the epidermis of some peach cultivars. However, no extensive epidermal tissue injury was observable from any of the $CaCl_2$ concentrations used in this study.

The shelf-life of peaches treated with 2 or 4 percent $CaCl_2$ in combination with captan was greater than 35 days, as compared with untreated fruit whose shelf-life was less than 6 days at 4°C (Table 2). Additionally, these two treatments resulted in 25 and 35 percent marketable fruit after 8 wk of storage (Fig 1). As expected, calcium concentration of the peel tissue of 'EarliGrande' peaches was highest in fruit dipped in 8 percent $CaCl_2$ and the lowest in fruit dipped in 0 percent $CaCl_2$ (Table 2). While captan treatment alone was ineffective, all $CaCl_2$ treatments better than doubled shelf-life and some tripled that of untreated fruit (Table 2). Fruit treated with 6 and 8 percent $CaCl_2$ with or without captan were not different but 2 and 4 percent $CaCl_2$ captan were obviously synergistic in their effects on the shelf-life. Even though in this study we kept peaches marketable for 56 days (Fig. 1), under normal storage practices, peaches are held marketable in storage at 4°C for 14 days or more. Peaches stored at 4°C for more than 28 days may be gradually affected by internal breakdown (Redit, 1969).

Calcium extends shelf-life and marketability of peaches by enhancing fruit texture and firmness (Singh et al., 1982). Calcium plays an important role in the maintenance of cell wall structure, especially in the crosslinking of polyuronide chains of the middle lamella (Fry, 1988), and thus delays fruit senescence and confers resistance to fungal infection (Sharples and Johnson, 1977). Preharvest sprays of calcium have been shown to reduce incidence of storage rot of peaches caused by *R. stolonifer* (Bhullar et al., 1981; Singh et al., 1982), although preharvest sprays add little calcium to peach tissues (Conway et al., 1987). The results of the present study suggest that a combination of calcium and captan as a postharvest spray or dip may significantly reduce storage rot of peaches caused by natural infection of *R. stolonifer*.

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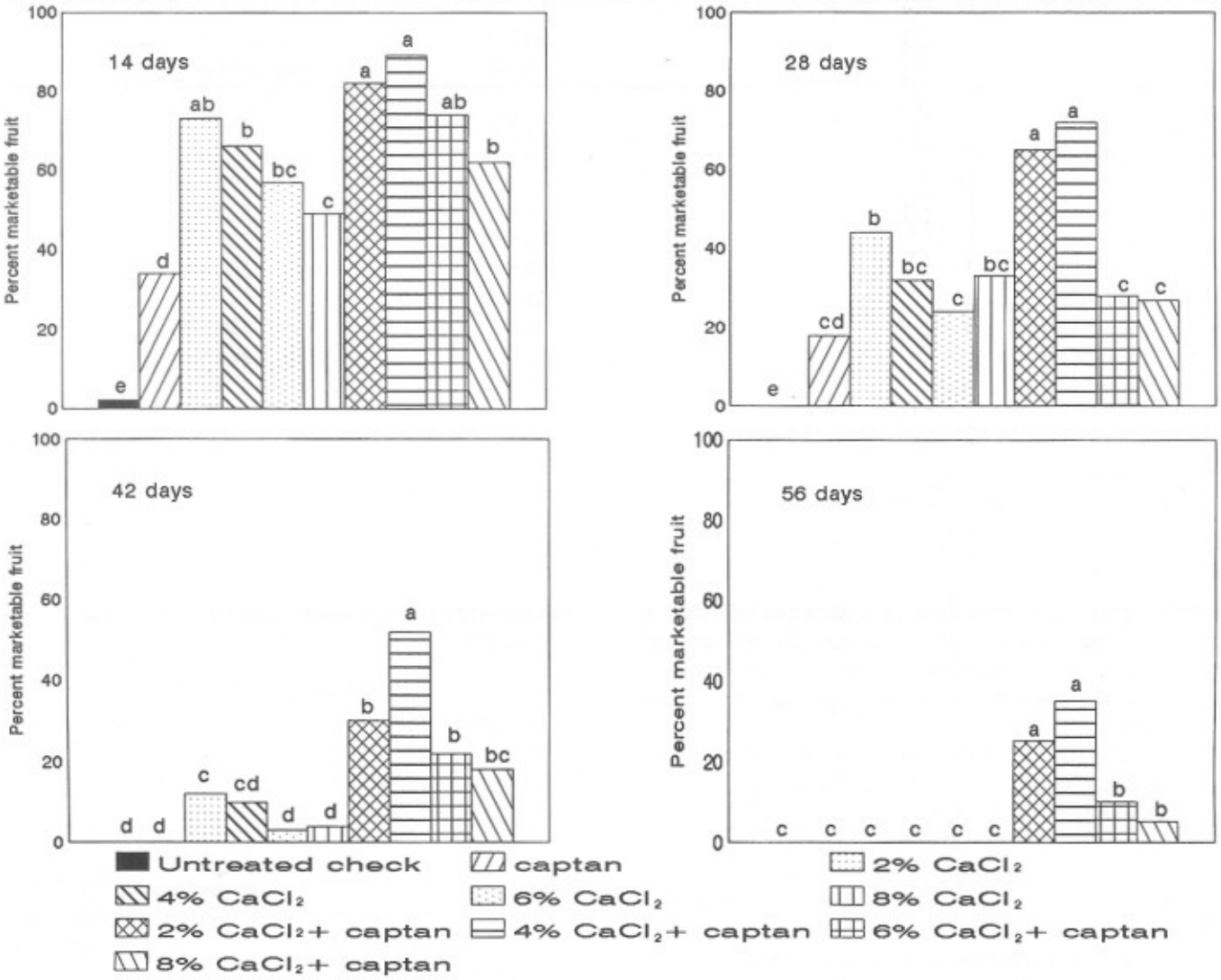

Fig. 1 Effects of calcium and captan treatments on marketability of 'EarliGrande' peaches stored at 4°C for 14, 28, 42 or 56 days. Treatments with same letter are not significantly different (P=0.05) according to Duncan's multiple range test.

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